

REMARKS

This Preliminary Amendment cancels original claims 1 to 11 in the underlying PCT Application No. PCT/DE03/02210 and adds new claims 12 to 22. The new claims conform the claims to the U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.125, the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including the Title and Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121 and § 1.125, a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. In the Marked Up Version, underlining indicates added text and "strike-throughs" and double-brackets indicate deleted text. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

Also enclosed is a translated copy of the International Search Report dated October 10, 2003. The Search Report includes a list of documents that were considered by the Examiner in the underlying PCT application.

It is asserted that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,
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FUEL INJECTOR

~~Background Information~~ FIELD OF THE INVENTION

The present invention ~~is based on~~ relates to a fuel injector ~~of the type set forth in the main claim.~~

BACKGROUND INFORMATION

5 ~~From DE~~ German patent document no. 198 04 463 A1, for instance, refers to a fuel-injection system for a mixture-compressing internal combustion engine having externally supplied ignition is known, which includes a fuel injector that injects fuel into a combustion chamber formed by a piston/cylinder
10 construction and has a spark plug which projects into the combustion chamber. The fuel injector is provided with at least one row of injection orifices distributed across the circumference of the fuel injector. By a selective injection of fuel via the injection orifices, a jet-controlled
15 combustion method is implemented by at least one jet in that a mixture cloud is formed.

A particular disadvantage of the fuel injector known from the aforementioned publication ~~is~~ may be the deposit formation in the spray-discharge orifices. These deposits clog the orifices
20 and cause an unacceptably high reduction in the flow rate through the injector, which leads to malfunctions of the internal combustion engine.

MARKED UP VERSION OF
SUBSTITUTE SPECIFICATION

EV 321879424 US

~~Summary of the Invention~~

SUMMARY OF THE INVENTION

~~In contrast to the related art, the~~The fuel injector according to the exemplary embodiment of the present invention having
5 ~~the characterizing features of the main claim has~~may have the advantage that a guide region in the valve-seat body, which conically tapers in the discharge direction of the fuel, allows hydraulic self-centering of the valve-seat body on the sealing seat during closing of the fuel injector. This
10 prevents post-sprays and thus deposits in the region of the spray-discharge orifices and prevents an unacceptable flow reduction.

~~Advantageous further developments of the fuel injector specified in the main claim are rendered possible by the~~
15 ~~measures elucidated in the dependent claims.~~

Given an angle of the guide region of 2° to 7.5° with respect to the perpendicular line, spherical valve-closure members, which are able to be produced and installed very easily and inexpensively, may advantageously be used.

20 It is also advantageous that play existing between the valve-closure member and the valve-seat body has different magnitudes in the open and closed state of the fuel injector; this causes a slight impact pressure to build up, which leads to automatic centering of the valve-closure member.

25 Furthermore, it is advantageous if the sealing seat and the guide region are drilled and ground in one working step in a joint clamping, using the same axis of symmetry.

~~Brief Description of the Drawing~~

~~An exemplary embodiment of the present invention is represented in the drawing in simplified form and elucidated in greater detail in the following description.~~

~~The figures show:~~

5 BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a schematic section through an exemplary embodiment of a fuel injector ~~designed~~ according to the present invention, ~~and~~.

10 Figure 2 shows a schematic section through the exemplary embodiment of the fuel injector ~~designed~~ according to the present invention, in region II in Figure 1.

~~Detailed Description~~

DETAILED DESCRIPTION

15 An exemplary embodiment of the present invention is described below by way of example. Identical parts have been provided with matching reference numerals in all of the figures.

20 An exemplary embodiment of a fuel injector 1 according to the present invention, shown in Figure 1, is designed in the form of a fuel injector 1 for fuel-injection systems of mixture-compressing internal combustion engines having externally supplied ignition. Fuel injector 1 is particularly suited for the direct injection of fuel into a combustion chamber (not shown) of an internal combustion engine.

25 Fuel injector 1 is made up of a nozzle body 2 in which a valve needle 3 is positioned. Valve needle 3 is in operative connection with a valve-closure member 4, which cooperates with a valve-seat surface 6 positioned on a valve-seat body 5

to form a sealing seat. Fuel injector 1 in the exemplary embodiment is an inwardly opening fuel injector which has at least one - in the exemplary embodiment, two - spray-discharge orifice(s) 7.

5 Valve-closure member 4 is guided in valve-seat body 5 by gimbals. According to the exemplary embodiment of the present invention, a guide region 37 of valve-seat body 5 has a design that tapers conically in the spray-discharge direction. Beveled sections 38 on valve-closure member 4 guide the fuel
10 that is flowing through fuel injector 1 to the sealing seat and spray-discharge orifices 7. A detailed description of the measures according to the invention may be gathered from Figure 2 and the specification.

Seal 8 seals nozzle body 2 from an outer pole 9 of a solenoid
15 coil 10. Solenoid coil 10 is encapsulated in a coil housing 11 and wound on a coil brace 12, which rests against an inner pole 13 of solenoid coil 10. Inner pole 13 and outer pole 9 are separated from one another by a constriction 26 and interconnected by a non-ferromagnetic connecting part 29.
20 Solenoid coil 10 is energized via a line 19 by an electric current, which may be supplied via an electrical plug contact 17. A plastic extrusion coat 18, which may be extruded onto inner pole 13, encloses plug contact 17.

Valve needle 3 is guided in a valve-needle guide 14, which is
25 disk-shaped. A paired adjustment disk 15 is used to adjust the (valve) lift. Armature 20 is on the other side of adjustment disk 15. Via a first flange 21, it is in force-locking connection to valve needle 3, which is connected to first flange 21 by a welded seam 22. Braced on first flange 21 is a
30 restoring spring 23, which is prestressed by a sleeve 24 in the present design of fuel injector 1.

Fuel channels 30, 31 and 32 run in valve-needle guide 14, armature 20 and along a guide element 36. The fuel is supplied via a central fuel supply 16 and filtered by a filter element 25. A seal 28 seals fuel injector 1 from a fuel distributor line (not shown further), and an additional seal 37 seals it from a cylinder head (not shown further).

On the spray-discharge side of armature 20 is an annular damping element 33 made of an elastomeric material. It rests on a second flange 34, which is joined to valve needle 3 by force-locking via a welded seam 35.

In the quiescent state of fuel injector 1, armature 20 is acted upon by restoring spring 23 against its direction of lift, in such a way that valve-closure member 4 is held in sealing contact on valve-seat surface 6. In response to excitation of solenoid coil 10, it generates a magnetic field that moves armature 20 in the lift direction, counter to the spring force of restoring spring 23, the lift being predefined by a working gap 27 that occurs in the rest position between inner pole 12 and armature 20. First flange 21, which is welded to valve needle 3, is taken along by armature 20, in the lift direction as well. Valve-closure member 4, being connected to valve needle 3, lifts off from valve seat surface 6, and fuel guided, via fuel channels 30 through 32, is spray-discharged through spray-discharge orifice 7.

If the coil current is interrupted, following sufficient decay of the magnetic field, armature 20 falls away from inner pole 13 due to the pressure of restoring spring 23, whereupon first flange 21, being connected to valve needle 3, moves in a direction counter to the lift direction. Valve needle 3 is thereby moved in the same direction, causing valve-closure

member 4 to set down on valve seat surface 6 and fuel injector 1 to be closed.

In a part-sectional view, Figure 2 shows the detail of fuel injector 1 configured according to the exemplary embodiment of
5 the present invention, which is denoted by II in Fig. 1.

As already mentioned before, valve-closure member 4 is guided in valve-seat body 5 by gimbals. In general, inwardly opening fuel injectors, especially in conjunction with large seat angles, have the disadvantage that valve needle 3 does not
10 immediately close fuel injector 1 completely after striking the sealing seat. This causes a certain fuel quantity to be post-injected, which is undesirable. Since this is still happening in the combustion phase of the fuel/air mixture in the combustion chamber, the flame front penetrates as far as
15 the spray-discharge orifices 7. This causes an increase in deposits from combustion products in the region of spray-discharge orifices 7, resulting in clogging of spray-discharge orifices 7 and thus an unacceptably high reduction in the flow rate through fuel injector 1.

20 As a counter measure according to the exemplary embodiment of the present invention, a guide region 37 of valve-seat body 5 in which valve-closure member 4 is guided tapers conically in the flow direction. In this way the guide play between valve-closure member 4 and valve-seat body 5 differs in its
25 magnitude as a function of the lift of valve needle 3. When fuel injector 1 is closed, the guide play is at its lowest and occurs in an order of magnitude of approximately 4 μm . At maximum lift of valve needle 3 in the open state of fuel injector 1, the guide play is considerably greater and amounts
30 to 8 μm , for instance. The opening angle of conical guide region 37 ~~preferably lies~~may lay between 4° and 15°.

If fuel injector 1 is closed, the conicalness of guide region 37 causes hydraulic self-centering of valve-closure member 4. During its axial movement in the flow direction, valve-closure member 4 displaces fuel that is present in guide region 37.

5 The fuel thereby accumulates since guide region 37 becomes narrower in the flow direction. As a consequence, a pressure bolster is formed in the region of the valve-closure member in guide region 37, which hydraulically centers valve-closure member 4 within guide region 37. Immediately after the closing
10 operation, valve-closure member 4 thus seals across the entire sealing circumference at valve-seat surface 6 with respect to the sealing seat. Without this measure, valve-closure member 4 would strike valve-seat surface 6 eccentrically and be centered only after a certain period of time by the action of
15 a closing force exerted by restoring spring 23 via valve needle 3.

For the precise centering of guide region 37, valve-seat surface 6 and guide region 37 must be drilled and ground with a shared axis of symmetry, preferably which may be together and
20 in one clamping in a tool machine.

The present invention is not limited to the exemplary embodiments shown, but is also applicable to any other designs of fuel injectors 1.

~~Summary~~ABSTRACT OF THE DISCLOSURE

A fuel injector ~~(1)~~ for fuel-injection systems of internal combustion engines includes an excitable actuator ~~(10)~~, a valve needle ~~(3)~~, which is in operative connection with the actuator ~~(10)~~ and acted upon in a closing direction by a restoring spring ~~(23)~~ to actuate a valve-closure member ~~(4)~~, which, together with a valve-seat surface ~~(6)~~ formed on a valve-seat body ~~(5)~~, forms a sealing seat; and having at least one spray-discharge orifice ~~(7)~~ which is formed in the valve-seat body ~~(5)~~. A guide region ~~(37)~~, which is formed in the valve-seat member ~~(5)~~ and in which the valve-closure member ~~(4)~~ is guided, is configured in such a way that it tapers conically in a flow direction of the fuel.

~~(Figure 2)~~